

Autonomous Navigation Using LiAISON in the Earth-Moon System

Completed Technology Project (2013 - 2015)



Project Introduction

An innovative technique using satellite-to-satellite tracking for onboard autonomous absolute navigation has been conceived at the Colorado Center for Astrodynamics Research (CCAR) at the University of Colorado at Boulder. This technique, known as LiAISON (Linked Autonomous Interplanetary Satellite Orbit Navigation), is a groundbreaking and enabling technology that can dramatically reduce the cost and/or improve the navigation accuracy of spacecraft in the Earth-Moon system by placing a navigation satellite in orbit about a lunar Lagrange point. LiAISON supports NASA's roadmap of Communication and Navigation (TA05) and specifically supports the subsection of Position, Navigation and Timing. This is a feed-forward technology that extends to exploration activity at Mars, its moons, and asteroids. The LiAISON concept consists of collecting simple radiometric tracking signals between two or more satellites, and using those signals to supplement or replace ground-based tracking and navigation. Several architecture concepts are possible from cooperative LiAISON constellations to a single LiAISON based navigation beacon that provides a GPS-like capability for lunar missions as well as Earth orbiting satellites. This technology alleviates the heavy dependence on current ground-based time and state vector updates allowing spacecraft to do autonomous navigation updates on-board with only satellite-to-satellite radiometric data. By introducing a navigation beacon on a libration point orbiter, there will be less reliance on the Deep Space Network (DSN) and ground-based navigational support, ultimately reducing the communication requirements on the tracking services making them available for missions with less on-board autonomy. The proposed research will focus on crewed and robotic missions in orbit about Earth-Moon Lagrange points and will: (1) replicate CCAR's success with LiAISON using operational JPL navigation software; (2) evaluate LiAISON navigation on the ARTEMIS lunar mission; (3) characterize the improvement in autonomous on-board station keeping and maneuver executions; (4) determine how many DSN tracking passes, or complexes, may be removed from a mission and obtain equal or better navigation accuracy; (5) optimize LiAISON orbits and constellations to quantitatively evaluate their use in future mission designs; and (6) measure the improvement in navigation accuracy obtained by adding LiAISON to conventional DSN tracking schedules for a variety of crewed or robotic missions, including lunar orbiters, and libration orbiters. The research primary deliverable is a quantitative evaluation of this new navigation technique in the context of the whole breadth of lunar exploration. This evaluation will include analyses to capture the costs (e.g., dedicated navigation satellite, additional hardware, etc.) and benefits (e.g., improved navigation accuracy, fewer DSN tracks, etc.) of LiAISON navigation applied to a variety of expected future missions. This project will provide the information that mission planners need in order to determine if LiAISON is practical for their mission. This proposal advances an innovative navigation technique called LiAISON that uses relative satellite-to-satellite range and/or Doppler measurements to determine the absolute states of both satellites. This navigation technology provides a major



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Organizational
Responsibility**Responsible Mission
Directorate:**

Space Technology Mission
Directorate (STMD)

Responsible Program:

Space Technology Research
Grants

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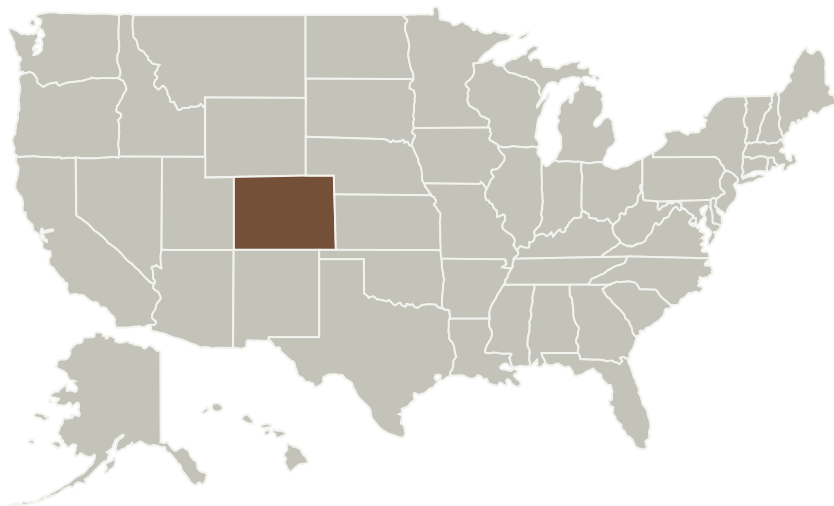


advancement in satellite navigation and maneuver design that may be used to improve navigation accuracy and/or reduce the amount and cost of ground tracking. The proposed research has the greatest impact on NASA's missions to the Moon. This research directly supports sending cargo and astronauts to a deep-space outpost beyond the moon's far side ultimately laying the groundwork for more ambitious manned missions to Mars. The results of this research provide a feed-forward technology that extends to GEO missions, asteroid missions, other missions in the Earth-Moon system, and Mars missions.

Anticipated Benefits

This navigation technology provides a major advancement in satellite navigation and maneuver design that may be used to improve navigation accuracy and/or reduce the amount and cost of ground tracking. The proposed research has the greatest impact on NASA's missions to the Moon. This research directly supports sending cargo and astronauts to a deep-space outpost beyond the moon's far side ultimately laying the groundwork for more ambitious manned missions to Mars. The results of this research provide a feed-forward technology that extends to GEO missions, asteroid missions, other missions in the Earth-Moon system, and Mars missions.

Primary U.S. Work Locations and Key Partners



Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

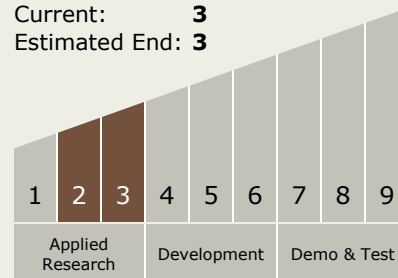
George Born

Co-Investigator:

Jason M Leonard

Technology Maturity (TRL)

Start: 2
Current: 3
Estimated End: 3



Technology Areas

Primary:

- TX17 Guidance, Navigation, and Control (GN&C)
 - └ TX17.2 Navigation Technologies
 - └ TX17.2.1 Onboard Navigation Algorithms

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Organizations Performing Work	Role	Type	Location
University of Colorado Boulder	Supporting Organization	Academia	Boulder, Colorado

Primary U.S. Work Locations

Colorado

Project Website:

<https://www.nasa.gov/directorates/spacetech/home/index.html>